Astron. Nachr./AN **xxx** (xxxx) x, xxx–xxx

New radio halos and relics in clusters of galaxies

G. Giovannini[1,2], L. Feretti[1], F. Govoni[1,3], M. Murgia[1,3], and R. Pizzo[1,4]

[1] INAF, Istituto di Radioastronomia, via Gobetti 101, 40129 Bologna, Italy
[2] Dipartimento di Astronomia, Universita' di Bologna, via Ranzani 1, 40127 Bologna, Italy
[3] INAF, Osservatorio Astronomico di Cagliari, Loc. Poggio dei Pini, Strada 54, 09012 Capoterra (CA), Italy
[4] Kapteyn Astronomical Institute, Postbus 800, 9700 AV Groningen, Netherlands

Received <date>; accepted <date>; published online <date>

Abstract. We present here new images of relics and halo sources in rich cluster of galaxies and the correlation between the halo radio surface brightness versus the cluster bolometric X-ray luminosity.

Key words: galaxies: clusters: individual (A209, A548b, A1758) – radio continuum: galaxies – X–rays: galaxies: clusters

1. New radio halos and relics

The knowledge of magnetic fields in clusters of galaxies is important to confirm the existence of large-scale cosmological magnetic fields and to study their properties. It is therefore crucial to obtain detailed observations of radio halos and relics, since these extended sources can give observational constraints to the cluster magnetic fields strength and distribution. We present here new data for three clusters of galaxies: A209, A548b, and A1758. From the diffuse radio sources in these clusters, equipartition magnetic fields of the order of 0.5×10^{-6} Gauss are derived [1].

Abell 209. This cluster at z = 0.206 is dominated by a central cD galaxy located near the peak of the cluster mass distribution. X-ray data and optical density distribution show an irregular morphology with significant substructures suggesting the presence of a cluster merger (Mercurio et al. 2003). The VLA radio image after the subtraction of discrete sources (Figure 1) shows a giant diffuse radio halo at the cluster center, with a major axis size of $\sim$ 6' ($\sim$ 1.2 Mpc).

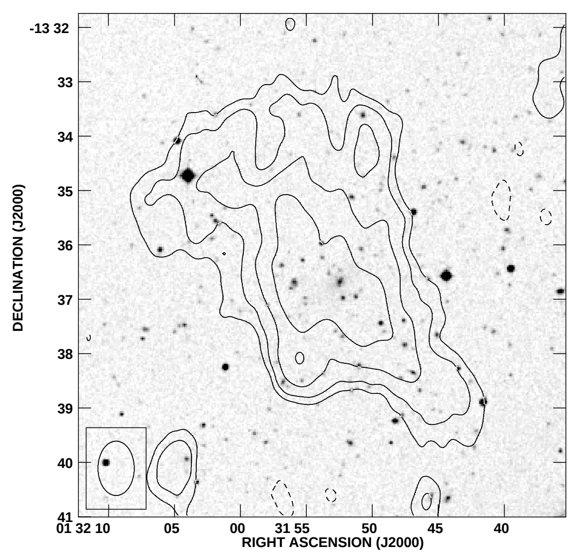

Fig. 1. VLA radio image (contours) of the giant halo in A209 overimposed to the optical map from the Digital Sky Survey (gray scale). The HPBW is 40"×60"; contours are: -0.2,0.2,0.3,0.5,0.8 mJy/beam. At the cluster distance, 1' $\sim$ 200 kpc.

Abell 548b. The cluster A548, at an average redshift z = 0.04, shows a rather complex structure with at least three main sub-clusters. The combination of X-ray and optical data indicates that A548 is a cluster in a collapsing phase and therefore not yet dynamically relaxed. Feretti et al. (2006) report the detection of two diffuse relic radio sources in A548b, confirming the association between relics and mergers. These sources are located on the same side of the cluster's X-ray center at projected distances $\sim$ 430 and 500 kpc, and show a similar shape, flux density, extent, polarization, and spectral index. Another diffuse source, probably a third relic, is detected close in projection to the cluster center (Figure 2).

Correspondence to: ggiovann@ira.inaf.it

[1] we use H_0 = 70 km sec^{-1} Mpc^{-1}; Ω_m=0.3,and Ω_Λ=0.7

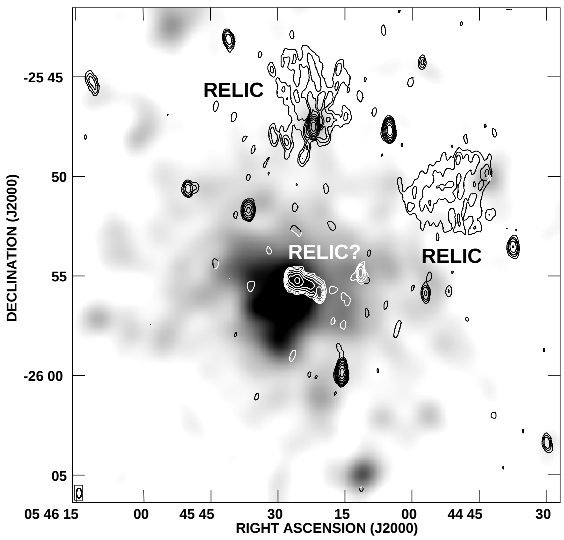

Fig. 2. Overlay of the VLA radio image (contours) onto the cluster X-ray image from ROSAT PSPC (gray scale). The radio HPBW is 15”×30”. Contours are: 0.3,0.5,1,2,4,8,16,32,64 mJy/beam. At the cluster distance, 1’ ∼ 50 kpc.

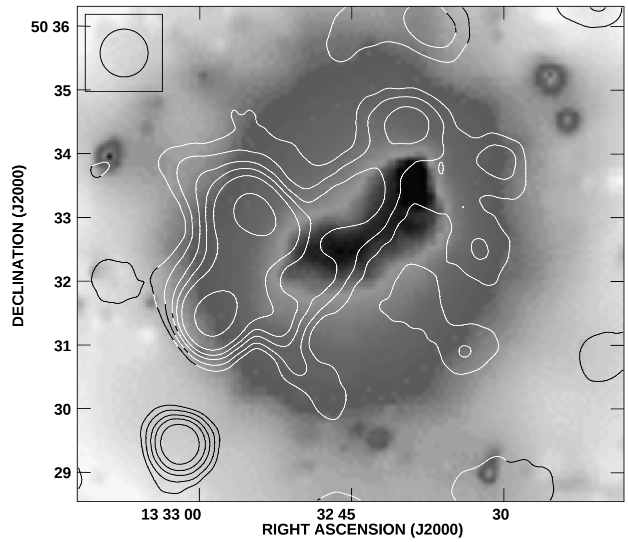

Fig. 3. VLA radio image (contours) of the extended radio structure in A1758N overimposed to the XMM X-ray image (gray scale). The HPBW is 45”; contours are: 0.15,0.3,0.5,0.7,1,2,3,5,7 mJy/beam. At the cluster distance, 1’ ∼ 250 kpc

Abell 1758. This cluster at z = 0.279 was studied in detail in the X-ray band by David & Kempner (2004). They showed that A1758 consists of two hot X-ray luminous clusters: A1758N and A1758S. The northern cluster is in the later stages of a merger of two 7 keV clusters, while A1758S is in the earlier stages of a merger of two 5 keV clusters.

We have detected a radio halo in A1758N. In Figure 3 we show a superposition of the halo source (discrete sources have been subracted) and the XMM cluster image. The radio image shows a diffuse emission (central halo) permeating the A1758N region where the two subclusters are merging, ∼ 0.8 Mpc in size, and two brighter peripheral structures on the opposite side with respect to the cluster center, which resemble relic radio sources. The detection of a radio diffuse emission in A1758N and not in A1758S is in agreement with the hotter temperature (7keV) of the N subclusters with respect to S subclusters (5 keV) and with the David & Kempner result that A1758N is in a late stage of merger, while A1758S is in an early merger stage.

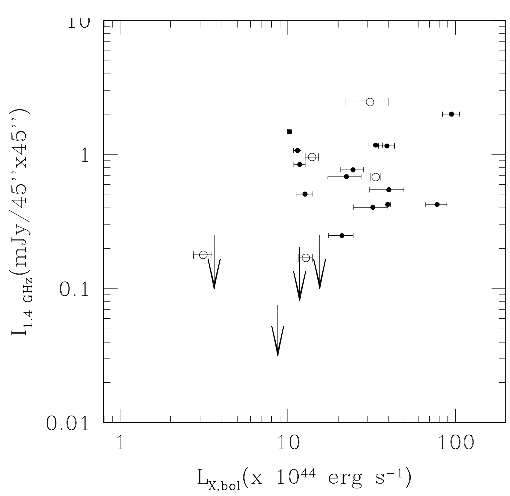

Fig. 4. Halo radio brightness at 1.4 GHz versus cluster bolometric X-ray luminosity. Upper limits (arrows) are A119, A399, A2111, RXCJ1234.2+0947. Empty circles are small size (< 1Mpc) halos.

2. Correlations

To understand the origin, evolution, and physical properties of radio halos and relics it is important to correlate the radio properties with cluster properties. Clusters with halos or relics are characterized by strong dynamical activity related to merging processes. Moreover the most powerful radio halos and relics are detected in clusters with the highest X-ray luminosity. However, halos are not present in all merger clusters. To take into account also upper limits to the radio emission for those clusters where a radio halo is not detected, Feretti (2005) presented the correlation between the average radio surface brightness of the radio halo versus the cluster X-ray luminosity. In Figure 4 we present this correlation including recent new data. It is interesting to note that upper limits are consistent with the correlation suggesting that low X-ray luminosity clusters might host faint radio halos which could be detected only by future telescopes as LOFAR, LWA, and SKA.

References

David, L.P., Kempner, J.: 2004, ApJ 613, 831
Feretti, L.: 2005, in http://www.aoc.nrao.edu/events/xraydio (astro-ph/0406090)
Feretti, L., et al.: 2006, MNRAS, in press
Mercurio, A., et al.: 2003, A&A 397, 431